

Kuldeep Purohit

Image Processing and Computer Vision lab

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RESEARCH INTEREST

Broad Areas: Image Processing, Computer Vision and Deep Learning.

Recent Work: Built models for restoration of images and videos suffering from blur, low-resolution, haze and noise and utilized them for scene segmentation or estimation of 3D geometry and motion.

EDUCATION

Indian Institute of Technology Madras, Chennai, India

January 2014 - present

MS+PhD in Image Processing and Computer Vision

Research Advisor: [Prof. A.N.Rajagopalan](#)

CGPA 8.43

Indian Institute of Technology Mandi, Himachal Pradesh, India

2009 - 2013

Bachelor of Technology in Electrical Engineering

WORK EXPERIENCE

Research Intern

December 2016 - May 2017

KLA-Tencor Corporation

Worked with E-Beam Wafer Inspection Team to design models for SEM image restoration and 3-D surface reconstruction.

Research and Teaching Assistant

January 2014 - Present

Indian Institute of Technology Madras, Chennai, India

Image Processing and Computer Vision lab, Department of Electrical Engineering

Intern

December 2011 - January 2012

Center for Artificial Intelligence and Robotics, Defense Research and Development Organization, India

Worked with Computer Vision Group on algorithms for vehicle tracking in UAV Imagery.

Project Assistant

May 2012 - June 2012

National Institute of Technology Bhopal, India

Literature review on Nano-materials and molecular electronics.

PUBLICATIONS

1. *Kuldeep Purohit*, Anshul B. Shah, and A.N. Rajagopalan, "Bringing Alive Blurred Moments," Accepted at International Conference on Computer Vision and Pattern Recognition (**CVPR**), 2019.
2. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Mixed-Dense Connection Networks for Image and Video Super-Resolution," Accepted at **Neurocomputing**, 2019.
3. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Scale-Recurrent Multi-residual Dense Network for Image Super-Resolution," In the European Conference on Computer Vision (**ECCV**) Workshop on Perceptual Image Restoration and Manipulation, 2018.
4. Srimanta Mandal, *Kuldeep Purohit*, A.N. Rajagopalan, "Color Image Super Resolution in Real Noise," In ACM Indian Conference on Computer Vision, Graphics and Image Processing (**ICVGIP**), December 2018.

5. *Kuldeep Purohit*, Anshul B. Shah, and A.N. Rajagopalan, "Learning based Blur Detection and Segmentation," In International Conference on Image Processing (**ICIP**), September 2018.
6. *Kuldeep Purohit*, Subeesh Vasu, A.N. Rajagopalan, Bala Naga Jyothi and Raju Ramesh, "Mosaicing Deep Underwater Imagery," In ACM Indian Conference on Computer Vision, Graphics and Image Processing (**ICVGIP**), December 2016.
7. *Kuldeep Purohit* and A.N. Rajagopalan, "Splicing Localization in Motion Blurred 3D Scenes," In International Conference on Image Processing (**ICIP**), September 2016.

Manuscripts Under Review

1. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Multi-level Weighted Enhancement for Underwater Image Dehazing," to Journal of the Optical Society of America A (**JOSA-A**), 2019.
2. *Kuldeep Purohit* and A.N. Rajagopalan, "Efficient Motion Deblurring with Feature Transformation and Spatial Attention," to International Conference on Image Processing (**ICIP**), 2019.

Manuscripts in Progress

1. *Kuldeep Purohit* and A.N. Rajagopalan, "Spatially Adaptive Residual Networks for Efficient Image and Video Deblurring".
2. *Kuldeep Purohit*, Subeesh Vasu, Poornachandra Rao and A.N. Rajagopalan, "Planar geometry and latent scene recovery from a single motion blurred image".

SCHOLASTIC ACHIEVEMENTS

- Finalist in all three tracks of the **Super-resolution Challenge**: Perceptual Image Restoration and Manipulation (PIRM) of ECCV 2018.
- Our work was selected for the **Best Paper Award** (Runner Up) at the Indian Conference on Computer Vision, Graphics and Image Processing (ICVGIP) 2018.
- Our team was a finalist at the the Annual Intelligent Ground Vehicle Competition (**IGVC 2017**), **Michigan, USA**.
- Ranked 13th among 4000 teams in the **Hackerearth** Deep Learning Challenge on Image Classification 2017.
- Received **travel grant** from IIT Madras to present my work in the International Conference on Image Processing (ICIP) 2016, Arizona, USA.
- **Scholarship** for under-graduate studies offered by Government of India, Ministry of Human Resource Development (2009-2011).

PROFESSIONAL SERVICES

- Reviewer** for the following conferences:
- Indian Conference on Computer Vision, Graphics and Image Processing (ICVGIP) 2018
 - International Conference on Signal Processing and Communications (SPCOM) 2018.
 - National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG) 2017
 - International Conference on Advances in Pattern Recognition (ICAPR) 2017
 - National Conference on Communications (NCC) 2017.

TEACHING EXPERIENCE	Assisted in deciding course contents, conducting lectures and evaluating tutorials and programming assignments for the following courses: <ul style="list-style-type: none"> • <i>Deep Learning for Imaging</i> under Prof. A.N. Rajagopalan and Prof. Kaushik Mitra • <i>Advanced Topics in Networks</i> under Prof. Avhishek Chatterjee • <i>Image Signal Processing</i> under Prof. A.N. Rajagopalan • <i>Introduction to Electrical Engineering</i> under Prof. A.N. Rajagopalan 	
SKILLS	Programming: Python, MATLAB, Latex, C/C++ (familiar), Lua (familiar) Libraries: PyTorch, Tensorflow, Torch, MatConvNet, OpenCV	
RECENT COURSEWORK	<ul style="list-style-type: none"> • Image Signal Processing • Digital Video Processing • Digital Signal Processing • Applied Linear Algebra 	<ul style="list-style-type: none"> • Deep Learning • Machine Learning for Computer Vision • Fundamentals of Linear Optimization • Probability Foundations
CONFERENCES AND WORKSHOPS ATTENDED	Conferences: <ul style="list-style-type: none"> • ICIP 2016, ICVGIP 2016, NCC 2016, ICVGIP 2014. Workshops: <ul style="list-style-type: none"> • <i>Workshop on Computational Brain Research</i> by Center for Computational Brain Research (CCBR), IIT Madras (2018). • <i>Summer School on Deep Learning for Computer Vision</i> organized by CVIT, IIIT Hyderabad (2017). • <i>Human Computer Interface</i> organized by Dr. Pradipta Biswas at IIT Mandi (2012). • <i>Swarm Robotics</i> organized by Robosoft Systems Inc., IIT Bombay (2010). 	
NATIONAL/ INTERNATIONAL TESTS	<ul style="list-style-type: none"> • GATE: 99.7 percentile in Graduate Aptitude Test in Engineering 2016: Post-graduate entrance exam of Indian Engineering Universities ($\approx 150,000$ participants.) • GRE: 320/340 (2012) • TOEFL: 98/120 (2012) • IIT-JEE: 99.0 percentile in Indian Institute of Technology- Joint Entrance Examination 2009: Under-graduate entrance exam for IITs ($\approx 400,000$ participants.) 	
EXTRA CURRICULAR	<i>PG Coordinator</i> Training and Placement Cell, IIT Madras Facilitated placements and training process and prioritized industrial opportunities for post-graduate students by inviting new companies for recruitment.	2014 - 2015
	<i>Member, Robotics Section</i> IIT Mandi Hosted competitions and organized an hands-on workshop with Robotech Labs, India.	2010 - 2011

Learning based sharp Video Extraction from a Single Blurred Image

IIT

Madras

Designed a deep convolutional architecture to extract a sharp video from a motion blurred image. The first stage involves unsupervised training of a novel spatio-temporal network for motion extraction from short video sequences. The above network is utilized for guided training of a CNN which extracts the same motion embedding from a single blurred image. The above networks are finally linked with our efficient deblurring network to generate the sharp video. Our framework delivers state-of-the-art accuracy in single image deblurring and video extraction, while being faster and more compact.

Mixed-Dense Connection Networks for Image and Video Super-Resolution

IIT

Madras

Proposed a deep architecture for image and video super-resolution, which is built using efficient convolutional units we refer to as mixed-dense connection blocks, whose design combines the strengths of both residual and dense connection strategies, while overcoming their limitations. We enable efficient super-resolution for higher scale-factors through our scale-recurrent framework which reutilizes the filters learnt for lower scale factors recursively for higher factors. We analyze the effects of loss configurations and demonstrate their utility in enhancing complementary image qualities. The proposed networks lead to state-of-the-art results on image and video super-resolution benchmarks.

Color Image Super Resolution in Real Noise

IIT Madras

Proposed an approach to super-resolve noisy color images by considering the color channels jointly in an optimization framework. Implicit low-rank structure of visual data is enforced via nuclear norm minimization in association with color channel-dependent weights, which are added as a regularization term to the cost function. Additionally, multi-scale details of the image are added to the model through another regularization term that involves projection onto PCA basis, which is constructed using similar patches extracted across different scales of the input image.

Learning-based Blur Detection and Segmentation from a Single Image

IIT

Madras

Designed a two-level architecture for blur-based segmentation of a single image. First network is a fully convolutional encoder-decoder for estimating a semantically meaningful blur map from the full-resolution blurred image. Second network is a CNN-based classifier for obtaining local (patch-level) blur-probabilities. Fusion of the two network outputs enables accurate blur-segmentation using Graph-cut optimization over the obtained probabilities.

Recovering sharp image and scene geometry from a single motion blurred image

IIT Madras

Designed an algorithm for recovering the latent image, planar geometry and camera motion from a single motion blurred image. Proposed a method to estimate planar surface orientation from blur kernels obtained from various location in an image. These estimates are fed into an alternative optimization based framework to jointly estimate the sharp image and plane-segmentation map.

Depth-based Segmentation and Camera Trajectory Estimation from a Blurred Image for Forgery Detection

IIT Madras

This work proposes an efficient algorithm for depth based segmentation using spatially-distributed blur-kernels present in a single motion-blurred image of a 3D scene. The segmentation is then further utilized to estimate global camera motion from a single blurred image of a 3D scene. Finally, local blur profiles are compared with the global motion model to highlight inconsistencies and detect spliced regions.

Multi-level Weighted Enhancement for Underwater Image Dehazing

IIT Madras

Attenuation and scattering of light are responsible for haziness in images of underwater scenes. We propose an approach to reduce this effect, based on the underlying principle

is that enhancement at different levels of detail can undo the degradation caused by underwater haze. The depth information is captured implicitly while going through different levels of details due to depth-variant nature of haze. Hence, we judiciously assign weights to different levels of image details and reveal that their linear combination along with the coarsest information can successfully restore the image. Results demonstrate the superiority of our approach over the state-of-the-art underwater dehazing methods.

Large-Area Mosaic Construction and Restoration of Deep Underwater Imagery

National Institute of Ocean Technology, India - IIT Madras

This work deals with the problem of mosaicing deep underwater images (captured by Remotely Operated Vehicles), which suffer from haze, color-cast, and non-uniform illumination. We propose a framework that restores these images in accordance with a suitably derived degradation model. Furthermore, our scheme harnesses the scene-depth information present in the haze for non-rigid registration of the images before blending to construct a mosaic that is free from artifacts such as local blurring, ghosting, and visible seams.

Denoising and enhancement of SEM images

KLA-Tencor - IIT Madras

Noise is very common in scanning electron microscope (SEM) images acquired with slow scanning and have a direct impact on further processing and defect detection. We analyzed the noise-related problems and developed a denoising approach based on multi-level detail enhancement. The enhanced images were used for segmentation and inspection of region-of-interest.

3D Surface Estimation using Multi-channel SEM

KLA-Tencor - IIT Madras

Developed a photometric stereo based algorithm for 3D surface reconstruction of semiconductor wafers captured using a multi-channel SEM. Incorporated domain-specific priors based on surface and sensor patterns in the optimization framework for robust estimation of the 3D surface structures.

Vision based Sign Language Translation System

IIT Mandi

Developed a learning based method to perform hand-gesture recognition using a Depth Aware Camera (Kinect). We utilized the captured RGB-D data to segment and track user's hands in real-time. We then trained a Convolutional Neural Network (on American Sign Language Dataset) to classify the segmented hand gestures.

REFERENCES

Prof. A.N. Rajagopalan

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Prof. Kaushik Mitra

Assistant Professor

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